X-17386

UNCLASSIFIED

BNL-2016

Subject Category: PHYSICS

UNITED STATES ATOMIC ENERGY COMMISSION

BUCKLING OF A NATURAL URANIUM LIGHT WATER MODERATED LATTICE

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August 23, 1954

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ATOMIC ENERGY COMMISSION ★ UNITED STATES OF AMERICA ★

UNCLASSIFIED

Work performed under Contract No. AT-30-2-Gen-16.

Date Declassified: November 9, 1955.

Printed in USA, Price 15 cents. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

BROOKHAVEN NATIONAL LABORATORY

M E M O R A N D U M

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Buckling of a Natural Uranium Light Water Moderated Lattice

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BUCKLING OF A NATURAL URANIUM LIGHT WATER MODERATED LATTICE

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The Brookhaven National Laboratory Reactor Physics Group is measuring the pile parameters of a series of light water moderated, slightly enriched uranium lattices. We are measuring ϵ, p, f, M^2, B^2 for three different sizes of rods, three different enrichments, and five different water-to-metal ratios. In order to expand this investigation we decided to measure some of the parameters of a light water natural uranium lattice. The lattice we chose has a uranium rod size of 1.1" diameter, and a water-to-uranium volume ratio of 1.5.

This measurement has been performed twice before. The first measurement was done by a group at Oak Ridge in 1944. Their work is reported in CP 2048, and the cold clean values are plotted on figure 1. Their objective was to see if light water natural uranium had any possibilities as a production pile and so they only tried for enough accuracy to determine whether such a system was worth the time and effort of a full scale investigation. Since their results showed that such a system would not have the k_∞ needed for a production pile, the work was stopped at a very early stage.

The next group to experiment with this was the Swedish. This work was done by Rolf Persson and the final results are shown in figure 1.* Here again the main interest was to determine the possibilities of this system

* Private communication to the author.

as a going pile. The results generally agree with the Oak Ridge values, in that k_∞ for a natural uranium water lattice has a maximum near a water-to-metal ratio of 1.5 to 1 and at this maximum k_∞ is probably less than 1.00. Neither of the experiments was done with enough accuracy to allow us to use it as an extrapolation point for our data.

The method we used to determine the buckling of this lattice is the same one we used previously. We measure the axial attenuation for a number of assemblies. Each assembly has the same water-to-uranium ratio and an infinite water reflector. The only variable is the number of rods. These attenuation lengths are then fitted by a least squares method to

$$B^2 = \left(\frac{2.4048}{A\sqrt{N}+\lambda}\right)^2 - \left(\frac{1}{L}\right)^2$$

Where B^2 = Buckling (Material) (cm^{-2})

N = Number of Rods

A = $\left(\frac{\text{cell area}}{\pi}\right)^{1/2}$ (cm)

λ = reflector savings (cm)

L = Axial attenuation length (cm)

The results of this fitting procedure give the best B^2 and λ and their statistical errors.

The actual experiment was done in our facility at Building T-526. We fabricated 802 fuel assemblies. Each assembly consisted of a 2 S aluminum tube into which was sealed 15 standard BNL pile slugs. This gave an overall length of uranium of 5 ft. Figure 2 shows the dimensions of a typical slug and a typical rod. These rods were then inserted into tube locating plates

at the top and bottom of our water tank. This tank is 6 ft. in diameter, and 5 ft. high. On top of the lattice we constructed a graphite thermal column 4 ft. wide by 4 ft. long by 2 ft. thick. Into this thermal column we placed 2 Ra Be neutron sources giving us about 1 x 10^7 neutrons/sec. each. The fluxes in the lattice were measured by a small BF_3 counter. Flux was measured as a function of position with and without the sources. Three such assemblies were constructed. They contained 802, 631, and 469 rods.

The observed count rates and least squares fitted Ls for these lattices are shown in tables I and II. The B^2 and λ that fit this set of data best are

$$B^2 = \left\{-3.477 \times 10^{-4} \pm .208 \times 10^{-4}\right\} cm^{-2}$$
$$\lambda = \left\{12.06 \pm .62\right\} cm$$

In order to check the effect of the background we eliminated all points with a count rate of less than 100 and recomputed the data. This gave

$$B^2 = \left\{-3.41 \times 10^{-4} \pm .158 \times 10^{-4}\right\} cm^{-2}$$
$$\lambda = \left\{12.02 \pm .46\right\} cm$$

which is in fair agreement with the other value.

It should be noted that the errors stated are only the random statistical errors and do not contain any possible systematic errors.

From our other light water uranium work we believe that the best M^2 for this lattice is 33 cm^2 which gives a k_∞ of .989.

In order to get a more accurate determination of B^2 and to measure ε, f, and p, we plan to put this assembly into our tank on top of the Brookhaven pile,

where the fluxes will be much higher.

The author wishes to thank Dr. Marvin Fox of the Reactor Department for the use of the uranium. Thanks are also due to the following workers on the above project: H. Kouts, G. Price, R. Sher, H. Connell, L. Heintze', L. McLean, J. Meyer, R. Rice, A. Sabosto, A. Tierney, J. Titmus, and V. Walsh.

Table I

Count rate (corrected for background) vs. position

Counter Position	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
	802 Rods	802 Rods	631 Rods	631 Rods	467 Rods	467 Rods	467 Rods
20 cm	795.5	799.9	748.9	739.6	650.7	692.1	693.6
30 cm	567.8	553.5	510.2	505.2	448.6	459.7	462.4
40 cm	392.6	399.6	344.3	349.8	290.3	305.6	305.8
50 cm	276.4	271.6	227.3	234.9	188.3	195.0	194.3
60 cm	194.4	190.9	161.1	161.5	122.4	129.0	129.9
70 cm	136.3	135.9	109.1	109.0	80.3	83.1	85.8
80 cm	93.2	94.3		75.7			

Table II

Run	L (All points)	L (Points $\geq$ 100)
1	28.029 cm	28.259 cm
2	28.107 cm	28.123 cm
3	25.916 cm	25.916 cm
4	26.222 cm	26.132 cm
5	23.663 cm	23.750 cm
6	23.553 cm	23.724 cm
7	23.790 cm	23.712 cm

FIG. 1

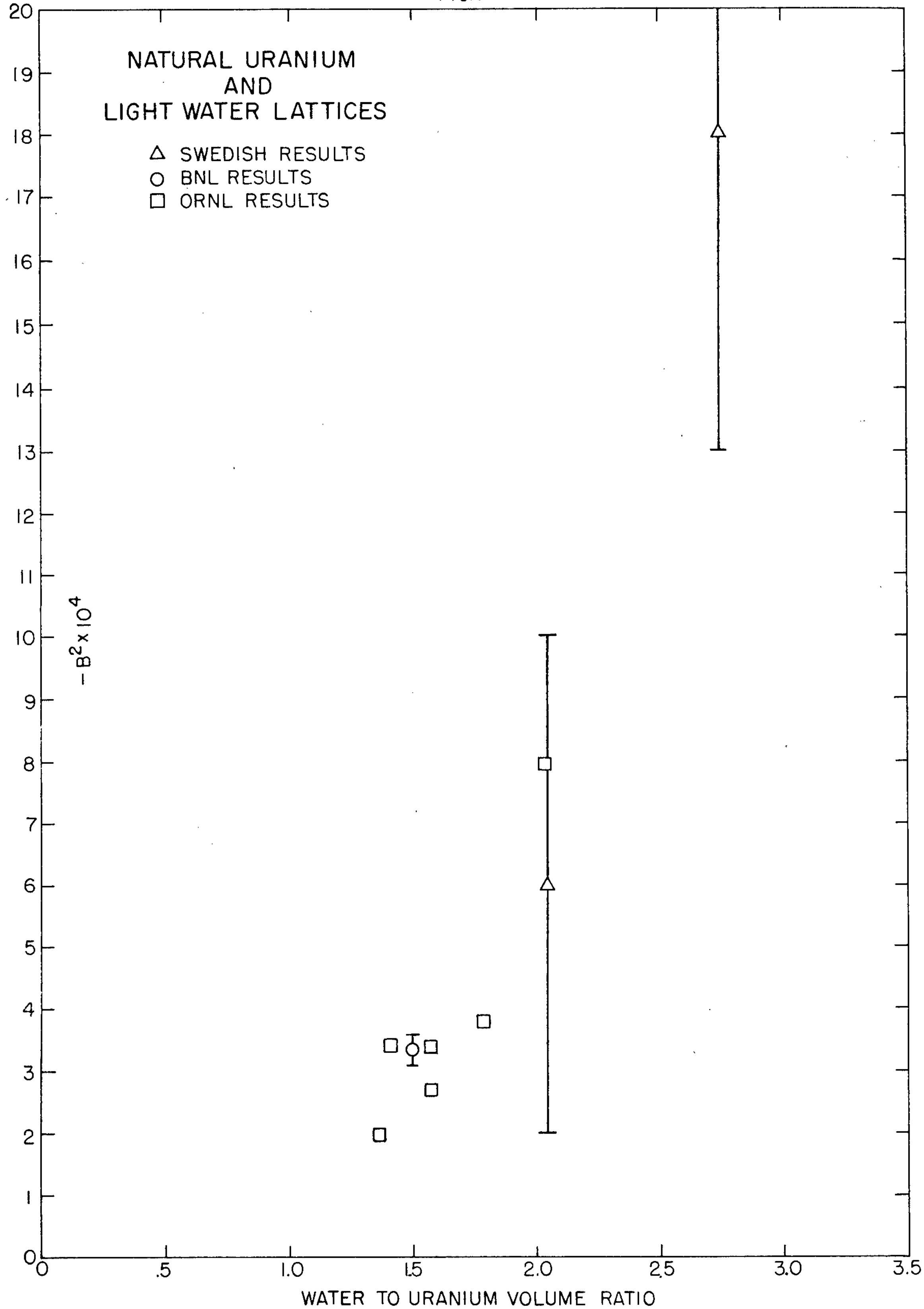
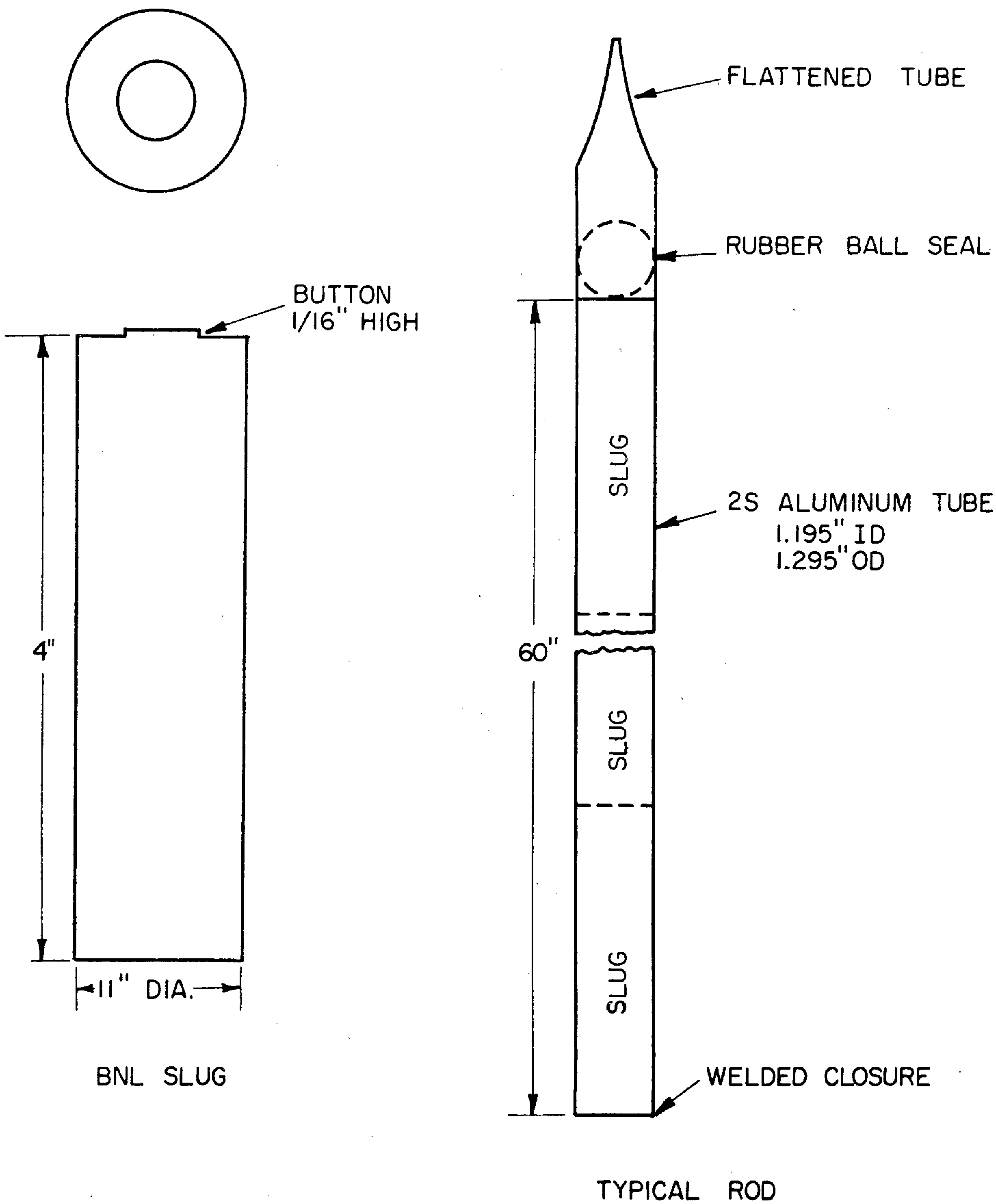

NATURAL URANIUM
AND
LIGHT WATER LATTICES
SWEDISH RESULTS
BNL RESULTS
ORNL RESULTS
$-B^2 \times 10^4$
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
.5
1.0
1.5
2.0
2.5
3.0
3.5
WATER TO URANIUM VOLUME RATIO

FIG. 2


BUTTON
1/16" HIGH
4"
11" DIA.
BNL SLUG
FLATTENED TUBE
RUBBER BALL SEAL
SLUG
2S ALUMINUM TUBE
1.195" ID
1.295" OD
60"
SLUG
SLUG
WELDED CLOSURE
TYPICAL ROD